THE LAW OF HEREDITY.

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It would prove, no doubt, a most difficult task, if it were, indeed, in the end possible, to decide—without a detailed analysis of their fundamental laws and the practical advantages they afford to mankind in general—which of all the sciences we are so far acquainted with is the most important. But, on the other hand, so much can be said with certainty that it does not require many arguments to show that the science which deals with the laws of heredity ranks amongst the very foremost branches of scientific doctrines. Put briefly, its claims to general and widespread recognition, on the part both of the lay public and of scientists, do not rest so much upon the facts concerning it which have already been brought to light, as upon the vast field of human well-being which it so intimately concerns. For, taking it as a whole, the science of heredity has to deal, not only with the transmission from parent to offspring of good or bad qualities and characteristics, as the case may be, but also with the whole chain of innumerable bodily and mental affections.

As a matter of fact, it is well to point out at the outset that, despite the great progress which, during the last one or two decades, has been made in this direction, it cannot yet be said that the final verdict on the main points at issue has been pronounced, and still less can it be said that all the biologists and scientific workers in this particular field of research have arrived at a clear and definite understanding concerning some vital questions in connection with that science. Moreover, the difficulties we have to contend with here become all the more obvious and remarkable if the highly important fact is duly taken into consideration, that our present knowledge regarding the very earliest stages of embryonic development is, in its principal points, de-

rived from observation in the animal and vegetable kingdom, though, on the other hand, it is safe to assume that the same processes take place in the human kind. However, some new and very important facts have come to light, and this especially during quite recent years, which will be illustrated and elucidated —as far as space permits—in the description that follows.

Of course, I am concerned here with the matter in question in its scientific aspect, that is to say, with heredity as a science only, and, therefore, leave out of consideration all the other allied subjects, such as genealogy and the like. What heredity, from the point of view of general science, really is may be briefly defined as the transmission of bodily or mental qualities or defects from parent to child or from one generation to another, though, so far as the strictly biological point of view is concerned, another statement is required—namely, that only those characteristics can properly be regarded as inherited which were contained in the original germ-plasm, paternal or maternal.

From the historic point of view it is interesting to note that this most important subject, as is indeed not unnatural, has commanded the attention and stimulated the thoughts of all kinds of thinkers and philosophers in all ages. For the facts that man belongs to a definite species, that races cling with the greatest tenacity to what are called racial traits, that individual shades of difference are so innumerable that amongst vast numbers of people no two beings are practically alike, and that families have certain definite and pronounced characteristics peculiar to themselves which can be traced through generations and generations past,—these facts demand explanation.

As regards the transmission of facial characteristics, it may not be out of place to mention that this particular branch of the science of heredity has, of late years, been studied, with a conspicuous amount of success, in connection with certain Royal Houses, since the family records, extending, in most instances, over centuries, are usually well preserved. Moreover, the work of the historian can in such cases be easily verified or modified, by reference to paintings and other reproductions of an illustrative royal character. Put briefly, from the results of this investigation, which has been carried out by various workers, it would appear that the transmission of facial traits is subordinate to a definite law—that is to say, that ancestral facial expression

and appearance are more often than not transmitted through the female members of a family, who generally do not exhibit the same characteristics, to the male offspring, and that the younger generations show, as a rule, all the facial conditions and signs which were present in a remote ancestor.

Further, as regards the inheritance of disease in general, the fact that disease is transmitted from generation to generation—there is some reference to this matter in Exodus: "The sins of the fathers shall be visited upon the children even unto the third and fourth generations"—must have impressed itself even upon those who lived in times when scientific observation and the laws to be drawn from its interpretation were very different from what they are in our present age of an advanced state of applied science. And so we have it that heredity has been studied more or less closely from, one may venture to say, prehistoric time.

There is an old saying that there is nothing new under the sun, and its truth is well illustrated by the theories which have been advanced, or indeed in some cases constructed, as it were, to explain the mechanism of heredity. When we take up the writings of one of the ancient scientists, Hippocrates, for instance, and study his views on subjects related to the science in question, and then turn, say, to Darwin, "the Aristotle of our day," as Francis Galton, in his famous treatise on Hereditary Genius, calls him, we find that Hippocrates in the main came to conclusions very similar to those which are embodied in Darwin's works. In his wonderful and admirable book on "The Air and the Water," Hippocrates relates the natural history of a certain tribe, the members of which were distinguished from other allied tribes by many striking external attributes, and notably by their long heads, and he offers, for the universal presence of this interesting feature amongst them, the following explanation—briefly stated. These people considered a "long head" especially beautiful; indeed, "they regarded it as an ornament," and, consequently, they moulded in this fashion the skulls of their children in the first months of life, when the bones are still soft and yield to pressure, and thus succeeded in producing the desired shape of the head. This practice was continued for some generations, when it was finally abandoned "on account of the children coming to the world shaped in this fashion." The theory propounded by this Grecian philosopher, who lived more than two

thousand years ago, concerning the transmission of *acquired* qualities, corresponds—in many details, one is inclined to say—to the Darwinian view, but with the difference, which, of course, scarcely requires to be pointed out, that Darwin, being able to make use of the great mass of scientific knowledge which has been gathered together throughout the centuries, and particularly in modern times, found but little difficulty in substantiating his arguments; whereas, on the other hand, Hippocrates had but little to support him, and he could not do much more than offer suggestions of a purely hypothetical character, as it were.

Speaking broadly, therefore, there is no getting away from the fact that what we know of heredity is not altogether a modern acquisition, that is, if all the necessary points are taken into due consideration. Again, it has been known, indeed, for a very long time, that hereditary traits are acquired about equally from the father and the mother, though it is only comparatively recently that the actual explanation of this has been forthcoming—that is, by the discovery of the rôle played by the chromosomes—certain bodies, which, as will be seen later on, appear in the course of division of the nucleus—in the productive cells, as well as in the first stage of embryonic development.

The day has not yet come for scientists to be agreed as regards all the essential features of heredity. As a matter of fact, the literature on the subject shows that marked differences of opinion prevail on points of great importance, this being to a very considerable extent due (1) to the fact that heredity was, and still is, for that matter, often confounded with several other subjects—such as, for instance, with the numerous forms of congenital and acquired properties—and partly also (2) to the misleading and quite unreliable results which have been obtained in studying the laws of transmissibility as they are manifest amongst the smallest animalculæ—that is, amongst the single-celled organisms which multiply by the process of the so-called "doubling division" only.

Another fact that has led to considerable confusion is that certain characteristics which occur in peoples and families who are exposed to the same climatic influences and the same modes of life in general have been supposed to be of an hereditary character. There is, for example, that disease which is fairly common in Alpine regions, struma. This pathological condition has been

supposed to be hereditary in character, but the fact is—and there are now few who would be inclined to argue this point—that it is wholly an effect of the climate, and of other certain conditions of a more or less terrestrial nature, to which parent and offspring are exposed alike.

Moreover, a great difficulty which faces those who study the subject is the uncertainty as to which is the work of original investigators and which is that of the critics. The difference, of course, between an investigator and a critic is clear; the former gives to the world nothing but the results of his own independent inquiries, the latter contents himself with criticising and analyzing what others have discovered. As the literature on the subject has increased—and it has done so very rapidly—the process of sifting the original matter from the critical has become more and more difficult, and is now more difficult than is indeed the case in any other branch of science.

For instance, during the last three or five years, a great number of books dealing with this very department of science have been published, yet it cannot be said that any of them has to any considerable extent added to the previous sum of knowledge regarding this vastly important subject. In reading such treatises, one cannot help being over and over again reminded of what Bismarck said to a foreign delegate to the famous International Conference in Berlin, who began, in a somewhat professional and very elaborate manner, to enlarge upon certain points which had already been considered as settled. "Sir," remarked the Iron Chancellor in his usual abrupt way, "you must excuse me for interrupting so much erudition, but I believe I have heard all this before."

As will be gathered from what has been said, no abstract science presents so many complex problems for solution as that which refers to the subject of heredity. On one point, however, there is so far a consensus of opinion—namely, that the offspring inherits from its parents inborn characteristics, bodily and mental, in almost equal proportions. As a matter of fact, this point can no longer be disputed. For, as I have already mentioned, the influence of the chromosomes—which make their appearance in the process of nuclear division, and owing to their physiological property of attracting certain stains can be discerned after treatment by means of some well-known reagents—in regard to hered-

itary transmission has been studied in its minutest details, and, as it would seem, the whole question has thus been placed beyond any further doubt. But, to cut a long story short, it may be briefly pointed out here that the very important question requiring elucidation, and which indeed is at present occupying the attention of the biologist, to the exclusion of all other considerations, is as to whether *acquired* peculiarities can be transmitted—that is, whether some mental quality or defect which a parent has acquired can be inherited by the offspring. Two of the greatest of scientists, in so far as this particular branch of science is concerned—Darwin and Weismann — differ widely on this point. According to Darwin and his school, the question is easy to answer, and this in the affirmative. For Darwin's famous theory of pangenesis advances, briefly stated, the view that very minute particles, which are named "gemmules" and which are believed to be derived from all the cells of the body, are lodged, as it were, in the reproductive cells, where they multiply by what is known as the process of fission, and where at some later stage they develop into the very same cells from which they originated, thus retaining all the existing parental properties, *inborn* and *acquired*. But, on the other hand, Weismann and his followers absolutely repudiate this theory, and maintain that, in the general act of reproduction, some "germ-plasm" is spontaneously separated or given off from the parent cell, and thus retained by the offspring. In the latter it remains—one has, probably, to imagine as an "image-in-little" of the adult, as was advocated by the old school of biologists of the fifteenth and sixteenth centuries—until it is passed on to the second generation, thence to the third, and so on. This constitutes what Weismann and his school term "the continuity of the germ-plasm," and it is held to explain, from the purely biological point of view, first, the perpetuation of *inborn* ancestral peculiarities, and, secondly, the *non-transmissibility of acquired* traits.

Again, as regards the practical side of the whole question, by far the most important point concerning heredity is, of course, the extent to which diseases are transmitted. The question which bears upon traits of character, and to which reference has just been made, is, no doubt, highly important also, but not so much so as that of disease. For, after all, character, as is well known, can be modified by environment and educational influence. As

regards the transmission of disease, there are the same two opposing views—denial and affirmation. Speaking generally, the theory which denies that disease can be directly hereditary would seem, in view of the recent interesting results which have been obtained from studying the question by way of pathological research, to be correct. For how is it to be understood that disease is directly transmitted from parent to offspring? To understand it, we should have to assume that the reproductive cells are affected with the particular disease, whatever it may be. But that is impossible. For there is the fundamental law in biology which is to the effect that, if once a cell is diseased, it no longer has the power to develop. Of course, there is another possibility, namely, that, though the reproductive cell is not in itself diseased, it is the receptacle, as it may be called, of a germ capable of producing a certain infection, much, say, in the same way as a capsule is the receptacle of some poisonous substance. But a disease transmitted in such a way—and which is now known amongst pathologists as "germinal infection"—would not be inherited in the strict sense of the word, for in discussing the possibility of an hereditarily acquired affection it is always understood that it forms part of the cell itself.

This general consideration is supported by many observations. In the first instance, supposing we accept the theory according to which, as we have seen, acquired bodily defects, whether of an external or internal character, are transmissible, we should expect to find, to mention a particularly well-known and striking case, that amongst Oriental nations that had long practised circumcision children would come to be born without a prepuce. But this is not so. It is true that a few such cases have been observed and described in medical literature, but they are purely abnormal and form just the exception which confirms the general rule. For, according to a quite competent observer, who lately published some interesting statistics bearing upon the subject, it would appear that similar cases occur just as often amongst nations that do not practise this custom. So much, then, as regards the case of transmission of external bodily defects. Then, also, if the spleen is, say, artificially removed, by means of one of the operations which have been invented for such a purpose, one would naturally expect that it would be either absent or degenerated to a considerable extent in the offspring. Numerous experi-

ments, however, which have recently been carried out by various observers with the same object in view, have elicited the interesting fact that no such result occurs. Those who favor the theory of the transmission of acquired defects, say, of an external character, endeavor to substantiate the view by instancing the South-American hornless cattle and the Manx tailless cats, which for generations have reproduced these characteristics. But they have failed to prove that they are not cases of atavism. Weismann, for instance, experimented with hundreds of white mice whose tails he had cut off, but in no single case was a tailless mouse born. In connection with this, it is interesting to note that similar experiments have lately been made by other—mainly French—observers, which were accompanied by the same negative result. Further, the advocates of the theory that acquired defects are transmitted also bring forward, by way of supporting their view, the contention that short-sightedness is inherited, and that the increased sense of smell which, as has recently been pointed out by a number of leading ophthalmologists, more often than not accompanies short-sightedness, is likewise derived by the offspring from the parent. But on neither of these points has it ever been demonstrated that it is not due to the conditions to which parent and child are alike exposed. In the animal kingdom, for instance, we can, of course, differentiate two quite distinct types of vision, some animals being far-sighted by nature, others short-sighted. The frog, for example, when out of water, can only see at a distance of about two or three inches, but this is quite far enough for his purpose of catching flies. The human being is naturally long-sighted. Thousands of aboriginals have been examined by various investigators, not so very long ago, and in not a single case has short-sightedness been discovered. The natural inference is that short-sightedness is acquired through modern conditions of life; and, as parents and offspring are exposed to these same conditions, the defect is much more likely to be the result of identity of environment and condition than of hereditary influence.

Finally, from the vast number of important facts which have been observed, and sufficiently studied and elucidated during recent years, one is justified in drawing the following conclusions:

1. Diseases, as such, whether inborn or acquired, are *never* transmitted; that, however, in the case of inborn affections, the

predisposition to the malady—but not the malady itself—is transmitted from parent to offspring. But the practical-minded person is very apt to ask what difference there is between the transmissibility of predisposition and the transmissibility of the disease itself, should the latter eventually develop in the offspring. The importance of this question can be shown without difficulty. In the case of tuberculosis, which until quite recently was genally regarded as an inherited disease, the latest scientific investigations have proved beyond doubt that it is not the germ itself that is inherited, but the *predisposition* to the disease. The importance of this discovery must be obvious, for, when there is predisposition only, there is the possibility of every care being taken to avoid all the injurious elements which might favor or give rise to the development of the disease. The children, therefore, of consumptive parents have thus a very good chance of remaining free from any ill effects. Tuberculosis is so widely spread and terrible a scourge as to suggest that it must in itself be hereditary, and it is, therefore, a long step in the right direction to learn that this is not actually the case, for it helps greatly to a better understanding of the means to be taken to suppress it.

2. *Acquired* external defects or mutilations of any kind are, as a rule, *not transmitted.*

3. As regards *acquired* pathological disarrangements of *internal* organs, there is some probability—judging at least from the results which have recently been obtained from certain experiments and operations on the nervous system—of their being transmitted from parent to offspring, but under quite definite and special circumstances, that is to say, if these internal lesions have caused the parent great suffering and called for much endurance.

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